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The development of a tool for assessing the environmental qualities of urban blue spaces

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ABSTRACT

It is well established that outdoor natural environments - or green spaces - have the potential to serve as therapeutic landscapes and are a public health resource. Less is known about the extent to which "water-related environments (blue spaces) - may benefit health. As with green space, health benefits resulting from blue space use probably depend on place quality. However, the lack of comparable environmental quality data hampers planning and design of blue spaces and their inclusion in public health-related policies.

This paper presents a novel tool - the BlueHealth Environmental Assessment Tool (BEAT) - which enables comparable assessment of environmental aspects and attributes that influence access to, use of and health-promoting activities in blue spaces. The tool is based on a review of published evidence and rigorous evaluation of 28 existing place assessment tools developed by and used in different disciplines including urban and transport planning, landscape architecture and management, urban design and public health.

The environmental attributes identified were assessed using a place affordance-affect scale based on their relevance to the interaction between the environment and human behaviour. This provided a framework for extracting those environmental variables especially relevant to blue spaces and for health determinants. These were incorporated into the BEAT as a set of domains each comprising several physical, social, aesthetic and environmental aspects.

The BEAT uses a questionnaire-based approach to examine each domain and aspect and to obtain both qualitative and quantitative measures using experience and judgment by either experts or stakeholders. The tool is freely available via an online interface featuring comprehensive guidance for assessors and a means of presenting results graphically. The tool can be used to compare sites before and after design interventions at a site. The BEAT enables rigorous and comparable assessment of the environment and strengthens the role of evidence-based planning in the development of urban blue spaces as a public health resource.

1. Introduction

1.1. Blue space attributes, health, and well-being

Blue spaces - outdoor environments, either natural or manmade - that prominently feature water and are accessible to humans either proximally (being in, on or near water) or distally/virtually (being able to see, hear or otherwise sense water) (Grellier et al., 2017, p. 3) can, like green spaces, have the potential as therapeutic landscapes and public health resources (Völker and Kistemann, 2011; Gascon et al., 2017). They may elicit psychological restoration (White et al., 2010; Gascon et al., 2017), promote physical activities (both land and water-based) (Barton and Rogerson, 2017; White et al., 2016a,b) and enhance social cohesion (Ashbullby et al., 2013). Blue spaces have been found to be highly preferred natural settings compared to other urban nature types (Korpela et al., 2010). As diverse environments, blue spaces may support different health and well-being benefits, depending on their type, quality, and characteristics (Völker and Kistemann, 2011, 2015; White et al., 2010).

While evidence suggests that certain qualities and characteristics of green spaces predict access and use (Zhang et al., 2017; van Dillen et al., 2012) more evidence is required regarding their salutogenic

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properties under changing urban environmental conditions (Grellier et al., 2017). A body of literature posits that various environmental aspects such as accessibility, safety, presence of facilities and levels of maintenance determine how a place is used (McCormack et al., 2010; Ward Thompson and de Oliveira, 2016). Natural features and biodiversity (Giles-Corti et al., 2005), neighbourhood attributes (Hamilton et al., 2017), incivility and disorder (Jones et al., 2011) and weather conditions (Humpel et al., 2002; White et al., 2013) all contribute to explaining place attractiveness and potential for use. Besides quality, quantitative measures of features and facilities e.g. the number of benches, length and width of paths, etc. also play key roles in promoting increased use of public space (Kaczynski et al., 2008). Given the wide range of attributes that have been identified as determinants of salutogenic environments, it is unsuprising that urban planners face a considerable challenge in creating spaces that afford health promoting behaviours and activities. Equally, limited attention has so far been paid to evaluating the qualities of existing places - especially blue spaces - which exacerbates the problems faced by a planner aiming to create healthy public space. The aim of this paper is to fill this gap by presenting a novel blue space quality assessment tool that serves the needs of a variety of stakeholders involved in planning and design.

1.2. Place quality assessment

To date, most outdoor environment assessment tools focused on health and well-being have examined urban built environmental components, play and sports environments, urban green spaces (i.e. urban parks and park components) and urban design qualities in relation to activities (Ward Thompson, 2013; Gidlow et al., 2012; Moudon and Lee, 2003; Bird et al., 2015). Assessment tools for urban public space design and management have focused on community environments and urban streets (Place Standard, 2015; Ewing and Handy, 2009), urban green and public open spaces (CABE, 2004, 2007; Green Flag Award Scheme, 2008; Gidlow et al., 2012; PPS, 2016), urban design quality (Wojnarowska, 2016; Natland, 2007) and urban woodlands (Ward Thompson and Roe, 2010). Some tools are available to assess the social impacts of urban regeneration, environmental impacts, management and ecosystem services associated with waterfronts and urban water environments (Sairinen and Kumpulainen, 2006; Gravagnuolo et al., 2015; Pompêo et al., 2011; Local action Toolkit, 2015), but these generally lack validation. Other work has produced tools which variously examine place quality and physical activity potential such as place features, activities, facilities, condition, accessibility, aesthetics, safety, natural features, incivility and signage (e.g. Joseph and Maddock, 2016; Bedimo-rung et al., 2005; 2006; Gidlow et al., 2012; Brownson et al., 2004; CABE, 2004, 2007; PPS, 2016).

Any environmental assessment of a blue space must include two related components: the terrestrial and the aquatic. In the Horizon2020-funded BlueHealth project (www.bluehealth2020.eu/) a need arose to create a tool that can be used to assess blue space environments comprehensively, especially in relation to their potential for promoting health and well-being. Thuis tool is known as the BlueHealth Environmental Assessment tool or BEAT for short.

1.3. Development of a conceptual framework

Lying behind the practical development and application of the new BEAT is the 'person-environment fit' theory (Suresh et al., 2006; Korpela et al., 2008) which helps us to define the blue space attributes that benefit health and which highlights the importance of key blue space physical environmental features (see Fig. 1). Physical environments influence human health in part through psychological and physiological restoration (Berto, 2014) that in turn depend on the capacity of both the people and the place to support various health outcomes (Stokols, 2003). Thus, the human capacity to transact with the physical environment depends on stimuli, sensory information and the perception of the degree of control by people over the environment which, together with adaptation and adjustment strategies, elicit different behavioural responses (Veitch and Arkkelin, 1995). These transactional parameters may be psychological or physiological and can be categorised into two ontological dimensions: environmental affordance (Hartson, 2003) and environmental affect (Bakker et al., 2014) (Fig. 2).

Fig. 1 highlights the potential relationship between blue space attributes and health determinants. Health determinants are the "active ingredients" in the environment that impact health and well-being positively or negatively (Kuo, 2015). Within this, the properties of the space generate affordances which support a range of potential activities (Gibson, 1979), and in turn these may promote behavioural and psychological responses. Blue space interventions, policies and management practices that originate from within the "person" dimension tend to improve physical characteristics that in turn enhance the blue space affordances and affects. Conversely, terrestrial and aquatic environmental conditions, qualities and impacts may independently and directly affect a population's exposure to blue space, positively or negatively influencing behaviour and psychology.

Fig. 2 highlights the importance of physical attributes of the outdoor environment within the nature-health relationship and elaborates on mechanisms that may influence pathways to health (Frumkin et al., 2017; USDA, 2018; Hartig et al., 2014). The relationship between blue space exposure and health determinants is mediated by the perceived affordances and blue space affects. The dimensions of affordances (physical, functional, sensory and cognitive) and dimensions of affect (pleasure, arousal and control and influence) may play a role in reinforcing the link between nature and health.

2. Materials and methods

2.1. Review search terms and process

In order to develop the BlueHealth Environmental Assessment Tool (BEAT) we carried out a comprehensive and systematic review of existing tools developed within various planning and public health disciplines. The review was first undertaken between December 2016 and March, 2017 and later updated during July and December 2017. We initially searched the academic and grey literature for place assessment tools using the search terms: "place assessment tools", "green space assessment", "green space audit", "environment audit", "place quality", "place character", "place assessment", "green space quality", "blue space"; "blue space quality", "water quality assessment", "urban water/stream quality", "urban design qiulity", "active living" using open web search, MEDLINE- PubMed, University of Plymouth Library and Estonian University of Life Sciences library search portals, Sciencedirect.com, MENDELEY and SCOPUS search engines etc. The identification of place assessment tools developed within public health research involved a manual search of the Active Living Research website (https://activelivingresearch.org/toolsandresources/all). The search focused on tools used for direct site observation and on-site field survey and excluded perceived (self-reported) models (Brownson et al., 2009). The tools included in the review were initially categorised into planning and public health disciplines and were then assigned into subcategories and areas of functioning and impact. Tables 1a and b in the Appendix illustrates all the important aspects of each tool.

The tools which we selected for detailed review following the search included place audit tools from fields including urban and community planning, transport planning, urban design and architecture, landscape architecture, park design and management, waterfront development, and public health. We were interested in tools developed anywhere in the world, which are well-documented and described, are or have been applied in practice and/or developed as part of a research project and written up in a scientific paper. Only tools described in English and published from 2000 onwards were considered. From the initial search

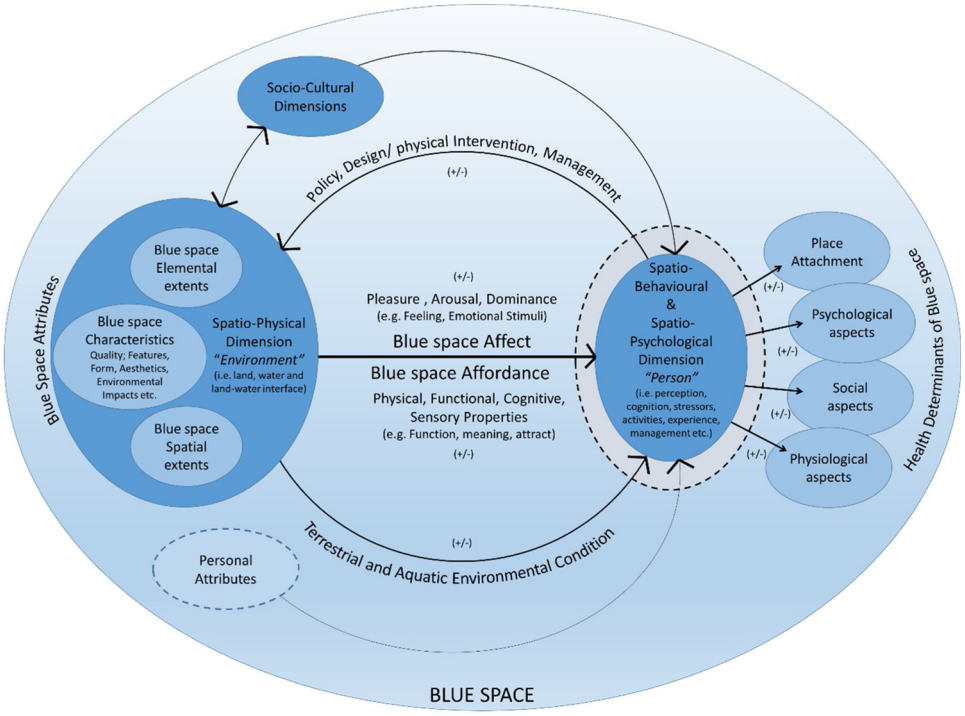


Fig. 1. The Person-Environment interaction model for Blue Space and health outcomes which forms the theoretical basis for the BEAT. On the left are the blue space attributes assessed by the tool and the rest of the model shows the pathways which lead to the expected health outcomes. (Author: Himansu Sekhar Mishra).

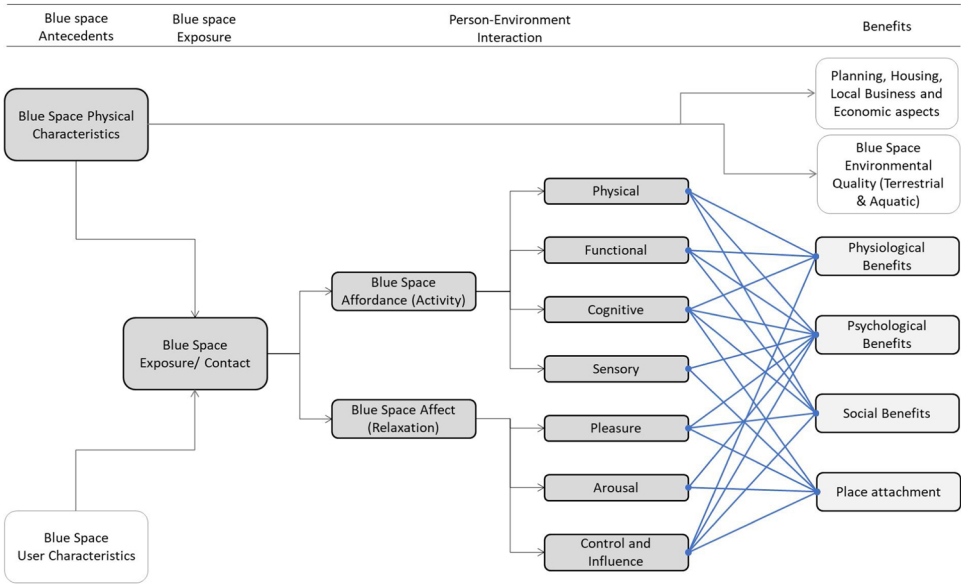


Fig. 2. An interaction model for Blue Space use for physical activities and relaxation. The unshaded boxes are potential blue space benefits unrelated to the person-environment interaction. (Author: Himansu Sekhar Mishra).

a total 39 place assessment tools were reviewed and a final set of 28 tools were selected as meeting our criteria for review. Of the total, eighteen tools originated from disciplines related to planning, design, and management of urban public spaces while the remaining ten were from the public health field.

2.2. Method of review and comparison

2.2.1. Data extraction and synthesis

The review first described tool characteristics such as the aim of the tool, field, and discipline of operation, etc. Some of the tool operational aspects were assessed such as tool length and complexity, data collection procedure, etc. We examined each tool to identify what features and aspects were considered for assessment and the measurement techniques used. We also evaluated the effectiveness of supporting documents, e.g. guidance notes that explain how to apply the tools.

Firstly, we looked at the basic characteristics of each tool:

- The objective and purpose of the tool, its scope, scale of coverage
- The tool development process as reported in the materials
- The structure, utility and operational aspects of each tool

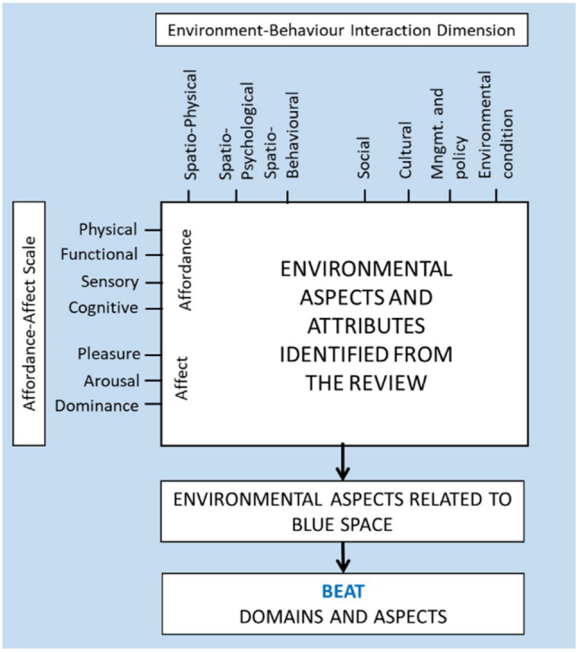


Fig. 3. Scheme presening the model for selection and categorisation of important physical environmental aspects extracted from the tool review for their relevance to health outcomes (also how it then feeds into the BEAT development process). (Author: Himansu Sekhar Mishra).

Secondly, we created a list of key words (based on their scope) to describe which environmental aspects each tool was designed to assess, and then grouped the key words together. The groupings were also related to the person-environment fit framework: whether spatio-physical, spatio-psychological or spatio-behavioural or external factors, including socio-cultural, management and policy aspects and environmental aspects (see Fig. 1).

This provided a framework for extracting those environmental variables most relevant to blue space environments and to place attributes for health determinants (Fig. 3). This was subsequently correlated with the eventual structure of the BEAT once it was developed (see below).

3. Results

The reviewed tools are summarised in Tables 1a and 1b in the Appendix.

3.1. Scope of the environmental assessment tools

3.1.1. Tool date, type, and field of operation

The tools reviewed were developed between 2000 and 2017. They primarily belong to the fields of urban planning, community planning, transport planning, urban design and architecture, landscape architecture, park design and management, waterfront development and public health.

3.1.2. Aim of the tool

Those tools developed to aid design and planning of public spaces generally focus on place quality and condition with the aim of improving the use and visitor experience (Gidlow et al., 2012; Place Standard, 2015; Ward Thompson and Roe, 2010; Sairinen and Kumpulainen, 2006). While some tools explore how places affect values and shape perceptions (CABE, 2004; Gravagnuolo et al., 2015), most assess quality, characteristics and sustainability of public or green spaces objectively (ASPiS, 2011; Green Flag Award Scheme, 2008; Ewing and Handy, 2009). With a focus on the urban-water environment, only one tool explores aspects of facilities, features, actions, regulations, and policies to improve place quality (Blue Flag Award, 1987; 2001) and one assesses ways to enhance blue space ecosystem services and benefits of green infrastructure within urban areas (Local Action Toolkit, 2015). Urban design criteria and principles have been used to assess public space qualities in town centres (Natland, 2007; Wojnarowska, 2016) and especially place success (PPS, 2016). Tools developed to support public health research tend to assess open and green spaces for their potential for physical activities e.g. play, sports, walking and cycling and use specific quality indicators such as place quality, characteristics, amenities, safety and maintenance (Brownson et al., 2009).

3.1.3. Tool development process

While there is wide variation in the way that the different tools have been developed, their structure and level of detail - in terms of number of factors and overlapping of factors assessed under different categories - a degree of consistency was found among those tools developed within public health. Within the planning discipline-related tools there is more variability in terms of subject selection and structure.

Depending on the different assessment purposes and scope of application to places of different sizes (e.g. ranging from small parks to national parks or cities) a narrower or wider range of environmental aspects tends to be included (Gidlow et al., 2012). Place selection criteria used to assess activities for health vary according to geographical location and size (e.g. extent and area) (Saelens et al., 2006; Tropped et al., 2006; Kaczynski et al., 2012). To assess street environments urban block segments have been used as study units (Brownson et al., 2004; Troped et al., 2006).

The most common methods for tool development stages include literature review (for identification of domains), reviews of best practice, community participation to identify relevant factors, use of Delphi studies with experts, selection of place or study setting, pilot testing, developing or using similar data collection methods, reliability and validity testing (Brownson et al., 2009) and training of assessors.

Some tools were developed by researchers as part of a project (e.g. BRAT-DO, PEAT, EAPRS, ASPiS), by experts or a combination of experts and activists in government or other agencies (e.g. POST, the Place Standard, Local Action tool kit, Spaceshaper or the WIAT tool) or NGOs (the PPS or Landscape evaluation and quality survey). Thus they can be described as a mixture of top-down and bottom-up approaches as well as a mixture of data-driven (e.g. the Feedback 4 Urban Facelifts) and expert-driven approaches, where a range of experts apply their knowledge (such as the Assessing social impacts in urban waterfront regeneration and Model for Assessment of Public space quality in Town Centres) which are then tested by application (e.g. the ASPiS star rating tool).

3.1.4. Type of places, behaviour settings and scale of the place under assessment

Most tools assess parks, a range of different types of green area and whole neighbourhoods and if they consider water at all, then it is as part of green space or as subsidiary landscape feature. Very few – in fact only four – specifically deal with waterfront or water spaces. Two tools assess urban streams, beaches, and marinas and have specific social or environmental assessment objectives (e.g. SIAUW, Local Action Toolkit). The Blue Flag scheme is focused on bathing beaches and waters. The Local Action Toolkit looks at urban water in quite a holistic way, while The Urban Stream Condition (USCA) focuses on water quality and ecology.

Audit tools developed within public health assess public open spaces (Broomhall et al., 2004), neighbourhood environments (Hoehner et al., 2007), park design and amenity standards (Bedimo-Rung et al., 2006; Kaczynski et al., 2012), public recreation spaces (Cavnar et al., 2004; Saelens et al., 2006) and paths and streets (Brownson et al., 2003; Tropped et al., 2006; Emery et al., 2003) for physical activity.

Since many tools are intended to be used by local community groups the scale and boundary definition of the space is intended to be set by the group carrying out the assessment rather than being a formal, eg ownership or administrative, boundary. In one specific case, the areas for assessment aim to be much larger – the Local Action Toolkit for river catchments sets the urban part within the context of the whole river catchment.

3.1.5. Intended users and application of the tool

Irrespective of the discipline within which each tool originates or operates, the intended users are mainly built environment professionals, public health researchers and various policymakers such as planning officials. Built environment professionals include planners, landscape architects and landscape managers. Many tools are designed for use by local communities and NGOs (e.g. Place Standard, WIAT, ASPiS, Blue Flag Award, PPS, LAT, ACN, CPAT) and for city authorities making decisions for green space development and management.

Most of the tools adopt a questionnaire-based approach and each section (such as a domain or aspect) is examined via one or a set of questions. Some questions are qualitative and require experience and judgment by experts or discussion with local people to obtain data; some use checkboxes to record presence or absence of features but most adopt a simple scale (e.g. a Likert scale) for rating the quality levels of the various environmental aspects they record.

Most tools are applied on-site, filling in forms or checklists on paper, possibly preceded by pre-site desk work to collect and assess base information, especially regarding the wider context and site surroundings. One tool includes the use of geographical information systems (GIS), particularly for larger sites and geographical position systems (GPS) to record locations or routes (Tropped et al., 2006).

3.1.6. Data interpretation and presentation of results

Once data have been entered into the tool the results need to be analysed, interpreted and presented. We only found one tool, the Place Standard, where a free web-based interface allows users to fill in a set of ratings and text and which then produces a pdf report of the results. Tools developed as part of research projects in public health or those developed with experts in mind were found to be more complex, detailed and comprehensive than tools developed by or for use by NGOs and communities. The presentation of results tends to include a mixture (depending on the format) of text reporting of qualitative findings, graphs, and charts for numerical scores such as those from scales or presence/absence recordings. Graphic presentations such as the “spidergram” were found to be effective ways to communicate results, especially if tools were used to compare before-and-after assessments.

3.1.7. Methods of measurement

The types of measurements used by the reviewed tools are wide-ranging. However, a majority used some type of numerical recording systems such as a Likert or Likert-type point scale, dichotomous scale, presence/absence checklist, multiple choice checklist, counts of numbers of occurrences of specific attributes and physical measurements. Most also have space for qualitative comments and observations to be made by the assessors.

3.1.8. Supporting materials and their usefulness

Most of the tools reviewed are accompanied by quite detailed guidance notes and instructions explaining how to apply the tools, usually available online to be downloaded. The guidance aimed at experts tends to be simpler and less attractively presented while those for community groups are more comprehensive, presented in clear language, contain worked examples and include instructions on how to set up workshops. Some use graphics and images to help navigate around the different sections. The ASPiS tool is unique in that it includes some serious games to help students understand what makes a sustainable public space. Websites for each tool help to make them accessible and may provide tutorials, examples of good practice and help to build a community of users.

3.1.9. Reliability and validity

Inter-expert reliability of assessment items ensures the robustness of a tool when measurements are taken on categorical scales and especially when the quality of the environment is assessed (Brownson et al., 2009; Pikora et al., 2002; Bird et al., 2015). Most research projects which developed tools also include a report of their reliability and validity. Tools developed for local community, city authority and NGO use are less likely to have reported reliability. Inter-rater reliability coefficients and observer percent agreement are common measures and, for a majority of tools, the reports show high levels of reliability among assessors following training. However, there also examples of poor agreement on maintenance quality, condition, land use information, technical information, disabled access, (e.g. PEAT), quality and quantity of walking path material, dimension, proximity, cleanliness (e.g. EAPRS, WABSA, POST), park quality, lighting, noise, and safety (e.g. CPAT), physical disorder, incivility, graffiti, traffic signs (e.g. ATCV, POST, NGST).

3.2. Domains used to define environmental factors

In the review, we looked very carefully at the common factors which are assessed by almost

every tool, as well as those less likely to be relevant for the specific objectives of the BEAT. The review looked very carefully at the common domains and factors which are being used by almost every tool to assess place qualities for place planning and design and health benefits, as well as those less likely to be relevant for the specific

Table 1
Environmental aspects identified during the review of the tool and their importance based on use frequency in percentages pertaining to planning and management, public health discipline and all tools together.

	Planning and management tools	Public health tools	All tools
Access and circulation	8.60	4.40	6.10
Cultural environment	2.00	–	0.80
Disabled access	1.20	1.00	1.10
Environmental impact	4.00	–	1.60
Environmental management	6.80	–	2.70
Historical and heritage environment	1.40	0.30	0.70
Management and maintenance	6.40	11.90	9.70
Management cost	0.20	–	0.10
Natural features and environment	5.40	3.30	4.10
Neighbourhood characteristics	2.00	0.30	0.90
Non-visual aesthetics	0.60	1.20	0.90
Place attachment	0.60	–	0.20
Place experience and comfort	6.20	2.50	4.00
Place use and activity	6.20	1.80	3.60
Planning and participation	1.80	–	0.70
Public amenities and facilities	4.40	8.00	6.60
Public transport	0.40	0.50	0.50
Real estate	0.20	–	0.10
Recreation amenities and facilities	3.00	12.70	8.90
Safety and security	11.40	11.60	11.50
Signage and information	4.60	8.00	6.60
Social environment	4.00	0.30	1.70
Spatial planning and design	2.40	3.00	2.80
Sports and play facilities and amenities	0.80	3.50	2.50
Street and path environment	0.80	18.70	11.60
Sustainability	2.60	–	1.00
Visual aesthetics	11.60	7.20	8.90

objectives of the blue sapce environment that BEAT aims to assess. A total of 27 different factors were identified that comprised a number of environmental attributes (Table 1). A total of 1264 attributes emerged from the 28 tools, although many were essentially identical, being named slightly differently. Across all tools, a key number of factors stood out as being almost universally important such as safety and security, the path environment, recreation and public amenities and facilities, visual aesthetics, access, and circulation. Table 1 shows the percentage of occurance of specific factors across all tools: note the wide range.

Taking the tools for public health assessed environmnets (e.g. community, park and public space, recreational and transporation environments) as a group shows a much wider range of frequency variability than for those relating to planning, design, and management as a group (Table 1). Attributes related to place quality, safety concerns and access and circulation are the most common, followed by attributes contributing to place success, use and experience, infrastructure provision and social environment. Attributes related to place use and activities, experience and comfort, place management, natural features, and signage were also frequently assessed. Research-based tools to assess environments for activities focus on path characteristics, recreational facilities, management and safety issues (Table 1). Tools to assess urban water environments focus on environmental quality, impact, the social impact of waterfront development and visual quality of waterfronts.

Among all 28 tools, a majority assess physical dimensions of the place followed by psychological and management dimensions. Behavioural and socio-cultural dimensions and environmental aspects appear to be considered as less important. Tools mainly assess factors we can connect with physical and cognitive affordances, while sensory and functional ones are less frequent (Table 2). In terms of place affect, pleasure and control and influence emerged as the most frequently assessed dimensions of relaxation (Table 2).

The review suggests that while physical dimensions of the environment are a focus of public health research-based tools (e.g. EAPRS, BRAT-DO, PEAT, WABSA), psychological and socio-cultural dimensions have a core importance in urban design and planning-based ones (e.g. APQTC, NATLAND; Space shaper: CABE, GSA: CABE, WIAT, UDQW). Management aspects were given equal importance in both categories while fewer behavioural aspects have been included in any tool. Environmental, sustainability, and policy aspects are largely confined to the planning and management of urban green and blue spaces.

4. Content and structure of the BlueHealth Environment Assessment Tool (BEAT)

4.1. Translation of the tool review findings to the BEAT concept

When reviewing and analysing the 28 tools as described above, a set of environmental aspects emerged to explain the structure, application and place characteristics and to provide an ontological framework.

Table 2
Tools assessing different environment-behaviour interaction dimensions and different place affordance and affect scales measures of the environment.

Affordance Affect Scale aspects	Percentage of occurance	Person-Environment Fit Aspects	Percentage of occurance
Arousal	2.2	Cultural	1
Cognitive	12.7	Environmental Aspects and Policy	4.3
Control and Influence	17.2	Management	11
Functional	2.6	Social	6.2
Physical	37.2	Spatio-behavioural	6.7
Pleasure	19.5	Spatio-physical	45
Sensory	8.4	Spatio-psychological	25.8

Generally, tools have a hierarchical structure based on a set of major topic themes or *domains* within which a selection of sub-themes or *aspects* can be found. These vary from tool to tool in how they are grouped and organised. Depending on the focus of a particular tool some domains and aspects are represented in greater depth than others. The use of an equally weighted domain/aspect structure is one way of enabling the assessment results to be comparable and to be able to see where a site may score higher or lower in different aspects within a single domain and then across different domains. This also helps when making decisions about what to do with a place or space and where to prioritise actions such as physical or social interventions to improve it.

We selected the set of domains and aspects for the BEAT (Fig. 5), identifying a number of areas which were weakly represented in the tool review in relation to the land-water interface, this being the focus of our new tool. We set up an overarching structure of *domains* as a relatively simple basis and then ensured, by reference back to the tool review and the categorisation of environment-behaviour interaction dimensions, that all *aspects* were covered. Fig. 4 presents a diagram mapping the results of the tool review to the emerging structure of the BEAT.

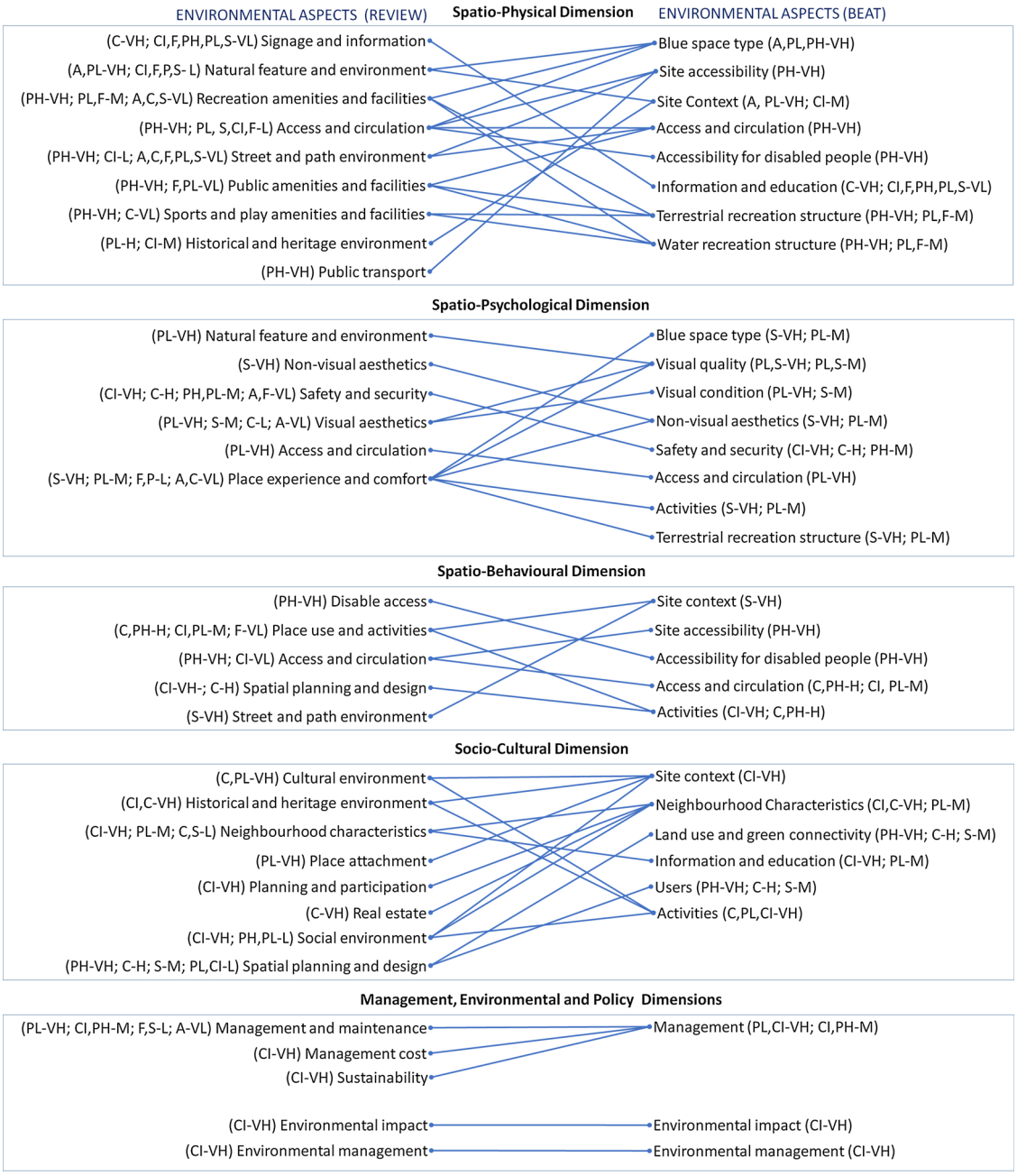
4.2. BEAT structure and content

When considering how tools were applied, there tended to be two or three stages, such as a preliminary desk study to obtain information (maps, data etc.) and to establish the site boundary to be assessed in context followed by an initial visit to obtain first impressions and a general overview followed by a more detailed, on-site assessment. The BEAT follows this approach: 1) Preliminary data about the site (macro-level assessment) 2) General site description (for first impressions), 3) On-site survey (micro-level assessment). Note that the tool content presented here does not assess water quality or ecologcal factors – there is a separate associated tool for this (to be reported separately).

4.2.1. BEAT structure for macro-level assessment

4.2.1.1. Preliminary data about the site. The preliminary data gathering stage is primarily a desktop study to explore the blue space context, type and surrounding components including geographical attributes and regional climate, site accessibility and the role of the site in the city or regional level blue space structure. Locational and contextual blue space aspects identified at this stage are:

1 Location
2 Name of site, survey grid reference/GPS coordinates, area (ha)/length (m or km)
3 Blue space type(s) (according to a list used in the BlueHealth project)
4 Site Context
  a Brief description of the site, its current uses, and general setting
  b Historical information about the site
  c Nature protection status, if any (Natura 2000 etc)
  d Symbolism and memory associated with the area if available (maybe more for local community groups)
  e General description of the surrounding landscape and setting (built form, natural elements, etc.)
  f General description of the waterbody and its wider connectivity in the hydrological system (character of the water, tidal or flow conditions, general quality,)
  g Accessibility to the site (terrestrial and water-borne)
5 The residential character of the neighbourhood (if relevant)
  a Property types and ownership
  b The population within 100 m, 500 m, 1 km
  c Socio-economic status
  d Ethnic composition (may be a problem in some locations due to local sensitivities or absence of data – should be checked)
  e Age structure



PH- Physical affordance, **F**-Functional affordance, **S**-Sensory affordance, **C**-Cognitive affordance, **A**-Arousal affect, **PL**-Pleasure affect, **CI**- Control and influence
VH- Very High, **H**- High, **M**- medium, **L**=Low, **VL**- Very Low

Fig. 4. Mapping across aspects extracted from the review to the BEAT aspects and their importance for their health antecedents. (Author: Himansu Sekhar Mishra).

6 Other green connectivity (e.g. other green/blue spaces within 100 m, 500 m, 1 km of the site)
7 Tourism and recreational infrastructure and attractions within 1 km of the site

4.2.1.2. General site description. This stage records a general description of the site under assessment, comprising a site map marked with different sub-areas or zones (using a standard legend) and calculated as percentages of the site. For a larger site, it may be necessary to subdivide it into major zones and repeat the above for each.

The first impression of the site is recorded based on the condition and activities taking place at the time of the survey. It is important because for visitors a first impression says a lot about a place and affects attitudes towards it and it also helps to put the detailed micro-assessment in context later on.

At this stage, the broad characteristics of the land-water interface and condition (Environmental Domain) are assessed (the water is subsequently assessed in detail using the specific part of the BEAT not presented in this paper). Table 3 presents these aspects:

4.2.2. BEAT structure for micro-level assessment

4.2.2.1. On-site survey. The main part of the assessment is conducted on site after the initial walk around and first impressions have been recorded. This survey can be repeated, for example before and after implementing a new design intervention or at different times of the year when activities may be different (eg winter vs summer). Each domain has a specific set of aspects to be assessed and ways of assessing them.

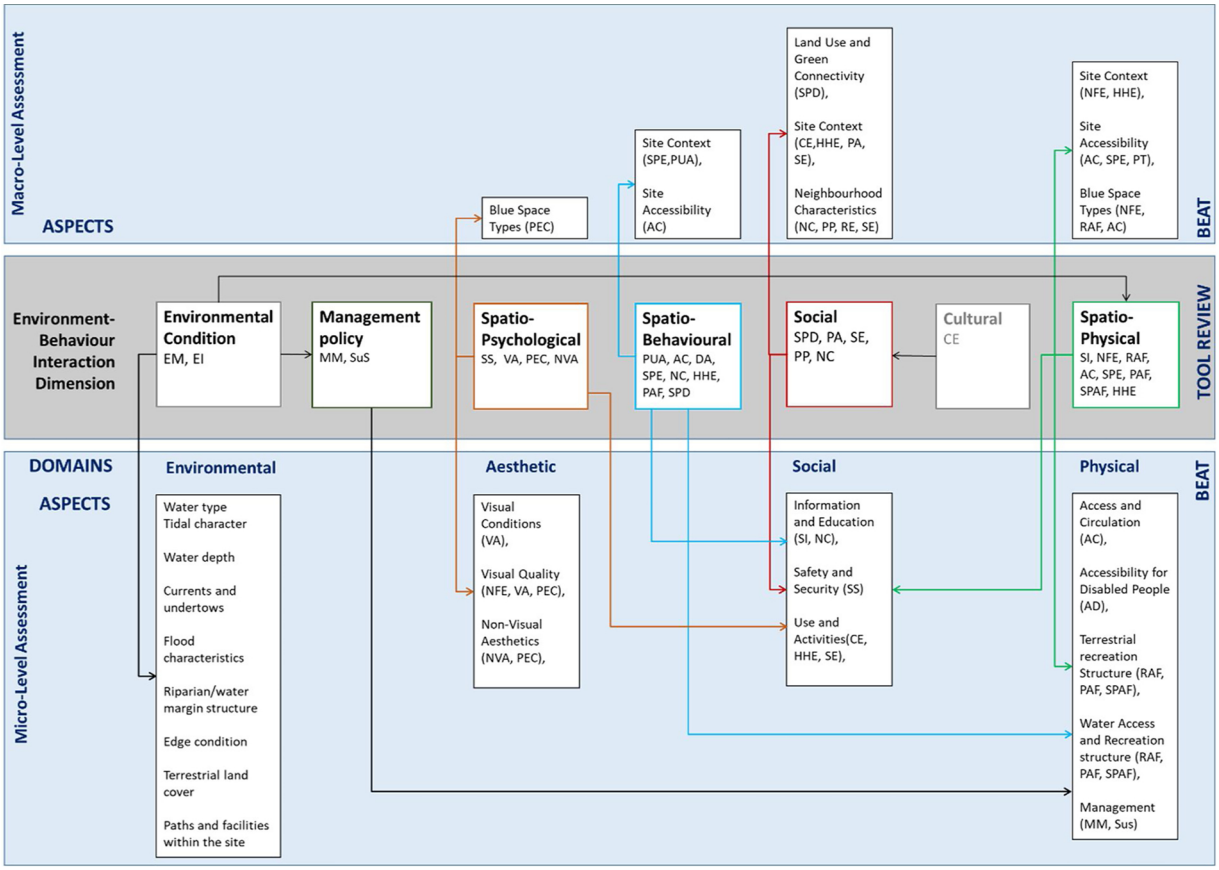


Fig. 5. BEAT domains and aspects derived from the review framework (Author: Himansu Sekhar Mishra).

Table 3
Aspects of the environmental domain.

Aspects	Assessment criteria
Open water	• fresh/salt • tidal/nontidal • running/still • depth
Riparian/water margin structure	• slopes (gradient) • embankments
Edges	• trees • reeds • shingle • sand • concrete walls • rip-rap
Terrestrial land cover	• grass • woodland • shrubs • hard surfaces
Paths and facilities within the site	• paths benches water access structures buildings

4.2.2.2. Social domain. The social domain within the person-environment interaction model includes spatial planning and design, place attachment, the social environment, planning and participation and neighbourhood characteristics as key elements. The social domain of the BEAT draws on different environment-behaviour interaction dimensions and includes key aspects of use and activities, safety and security, and information and education. Use and activity indicate place support for different behavioural dimensions as well as social activities and cohesion. While perceived community and personal safety and security enhance or inhibit the use of place, information and education provides social benefits and promote use. The BEAT social domain aspects are presented in Table 4:

4.2.2.3. Aesthetic domain. The spatio-psychological dimension focuses on visual aesthetics, place experience and comfort as well as non-visual aesthetics as place attributes that aid psychological restoration. The BEAT aesthetic domain aspects are presented in Table 5:

4.2.2.4. Physical domain. The physical domain draws on the spatio-physical, spatio-behavioural, and management aspects within the environment-behaviour interaction model. Access and circulation relating to blue space can be enhanced through improving site accessibility i.e. site locations and access points, vehicular access and parking provisions and access and circulation within the site through creating access infrastructure i.e. the walking and cycle path network, accessibility to water and play areas. Ease of access for people with disabilities is an important determinant for place success, which includes universal design considerations for paths and access routes, access to water, facilities and amenities. The terrestrial and water-based recreation structure aspect assesses all public, recreational and sports amenities and facilities present within the blue space. The management aspect covers site maintenance and sustainable practices. This domain covers the terrestrial part of the site and includes all constructed elements as presented in Table 6:

4.2.3. Selection of measurement types

For the BEAT measurement and recording system we decided to combine numerical scoring using a 5-point Likert scale where the quality of an aspect was important, as well as presence/absence and multiple choice checklists. For each aspect comments and observations can be recorded to supplement the scoring. This helps to establish a common means of comparing all aspects within each domain and between sites, to make the analysis process simpler and to produce clear

Table 4
Aspects of the social domain.

Aspects	Assessment criteria
Aspect 1: Use of the site and activities	1 Activities taking place on land and on or in the water (direct evidence) Negative or uncivil activities if seen should also be recorded. 2 Activities taking place from indirect evidence (traces left behind or from talking to people) on land and on or in the water. 3 An estimate of how many and what kind of people are using the site (age and gender, but not ethnicity) NB: Repeated visits across the year will reveal much more about the patterns of use.
Aspect 2: Information and education	1 Presence, and usefulness of information such as signs, 2 Presence and functionality of way-marking or directional signs, 3 Presence and clarity of codes of conduct/rules and regulations 4 Interpretive structures giving information of value to visitors of a cultural, historical or environmental nature 5 Accessibility of information for people with different types of disability 6 Presence of information in a range of languages.
Aspect 3: Safety and security	1 Physical safety and security against traffic and along water edges, 2 Presence of water safety equipment and lifeguards, 3 Presence and functionality of lighting, 4 Sense of general security against crime or anti-social behaviour, 5 Presence of vandalism or damage signalling lack of security, 6 Presence of threatening people, 7 Signs of alcohol or drug use,

Table 5
Aspects of the aesthetic domain.

Aspects	Assessment criteria
Aspect 1: Visual condition of the surroundings of the site	1 The visual quality of buildings and other structures visible along the site boundaries (landside) 2 Screening of off-site eyesores by trees and vegetation 3 Quality of views out from the site across the water 4 Sense of openness and scale of water views 5 Presence of focal points visible from the site 6 Visual pollution such as garish advertising
Aspect 2: Visual quality of the site	1 Quality of views within the site 2 Quality of views to the site from the water 3 The visual quality of built structures within the site 4 The attractiveness of vegetation on the site 5 Light pollution at night 6 Sense of wildness
Aspect 3 Non-visual aesthetic aspects	1 Smells and olfactory pollution 2 Sounds and noise pollution 3 Sense of atmosphere: wind, moist air, etc. 4 The feeling of tranquillity or calm

comparative graphics.

4.2.4. Expert assessment, guidance and training

Since the BEAT comprises both objective and subjective aspects, it is preferable to involve at least two assessors so that independent assessments can be made and compared. Differences in opinion among the assessment team can then be discussed and final scores agreed so as to ensure that personal biases do not unduly affect the final assessment.

To ensure a good quality and replicable assessment, reading the guidance is necessary followed by some practice and, ideally, training or guidance from people who have used it before. The guidance is essential for anyone using it for the first time, especially for those aspects which tend to be innately more subjective – such as visual aesthetics - where past experience or the assessor's personal standard for beauty, assuming aesthetics or beauty to be an intrinsic physical attribute of that specific environmental setting (Arthur et al., 1977), may need to be calibrated. It can also be assumed that local experts have knowledge on local culture, social norms and the meanings that local people attach to the place besides their in-depth knowledge of the relevant domain or topic.

It is also possible that planners might encourage communities to participate through "citizen science" and work together to collect data and to monitor sites (Dickinson et al., 2012). This method is used to collect data on urban wildlife by, for example, counting birds or other species (Rose et al., 2016; Lepczyk, 2005). Indeed, some members of local communities are knowledgeable about some areas, such as bird watchers or those engaged in recreational fishing, for example, whose expertise or tacit knowledge might be capitalised upon for the purpose of collecting good quality data.

We have also provided guidance and training to local experts as part of the BEAT development and testing phase (not reported here). The training protocol involves in-office training for two hours, briefing on the detailed BEAT manual and guidance, familiarisation with the assessment items, steps, and processes involved in an assessment, operational aspects of the online tool and on-site survey, safety precautions to be taken during the site survey and illustrative examples of ways of presenting results. The online interface has already been developed and is in the process of testing and refinement (available at https://bluehealth2020.eu/projects/ - interested readers can apply for a password). The online survey questions, the BEAT manual, information on climatic zones, blue space types and water quality types are available to download for reference during the assessment. The on site survey data can be entered online via a tablet or smartphone using mobile data services. A paper version of the survey questions is also available to download and use on-site, allowing the recorded data to be uploaded to the BEAT website later.

5. Discussion

To date, no tools have been developed for the comprehensive environmental assessment of blue spaces. We have developed the BEAT tool based on a review of existing similar place assessment tools and a gap analysis. The wide heterogeneity and scale, varying complexity and overlapping factors that characterise many existing bespoke place assessment tools posed challenges for the design of the comprehensive, robust and universal blue space assessment tool that we needed. The extension of the range of domains and aspects included within the BEAT to focus a) on blue space and b) on health and well-being is one of the main contributions to tool development we have made.

Regarding the health determinants of blues space, most of the reviewed tools focus on the spatio-physical and spatio-psychological dimensions of the environment-behaviour interaction. A screening of all the aspects using an affordance-affect scale suggests that tools mainly assess environments for physical and cognitive affordances while sensory and functional affordances are less-well captured. The functionality of space features, amenities and facilities are equally important so as to ensure the affordances are maximised and health benefit potential is maximised. Regarding environmental affects, tools mostly capture

Table 6
Aspects of the physical domain.

Aspects	Assessment criteria
Aspect 1: Access and circulation within the site	1 Access roads within the site 2 On-site car parking and its functional accessibility 3 Boat launching access and ramps 4 Footpath network and its functional accessibility (layout, desire lines, etc.) 5 Cycle path network and its functional accessibility (layout, desire lines, etc.) 6 Path construction and use of materials 7 The physical condition of paths (state of surfacing)
Aspect 2 Accessibility for disabled people	1 Physical disabilities 2 Blind and partially sighted 3 Deaf and hearing impaired 4 Mental and learning disabilities
Aspect 3: Terrestrial recreation structures (visual quality, functionality, condition)	Toilets, Changing rooms, Changing cubicles, Cafe/restaurant, Fountain, Art Installation, Children's play area, Safety equipment store, Watchtower, Observation deck, Food, and ice cream stall
Aspect 4: Water access and recreational structures (visual quality functionality, condition)	Boat slipway, Jetty, Pier, Dock edges, Marinas, Harbour or other retaining walls, Bridges, Locks, Paddling pool, Swimming pool
Aspect 5: Management and maintenance	1 Maintenance of hard surfaces 2 Management of vegetation 3 Maintenance of street furniture 4 Site maintenance in general (litter, dog mess) 5 Maintenance of play areas 6 Maintenance of safety equipment

the pleasure and control and influence dimensions of the place.

Not all environmental factors which emerged from the review were considered for the development of the BEAT. This was partly due to the objective of the BEAT to focus on the key aspects for blue spaces, to the anticipated scale of the assessment sites and also to develop the BEAT as a concise and comprehensive assessment tool which can be administered with ease. Though some tools propose a thorough investigation of places, they were found to be extremely lengthy and time-consuming to complete (e.g. EAPRS and PEAT). The lack of assessment tools for blue spaces made the process challenging and the review revealed that most place assessment tools have been developed to assess green spaces and urban built environments. However, a set of common environment aspects were found for assessing any public space and thus set the foundation for the criteria for the BEAT.

A literature review of correlation studies between physical characteristics and activity outcome supported the choice of aspects to be included in the BEAT. Even though some aspects are frequently found and some relatively less so, the relative importance of each aspect and their effect on activities is less conclusive (Pikoraa et al., 2003).

Research suggests that scoring of some items assessed subjectively (e.g. safety, incivility) may be found to be less reliable than items measured objectively (Bird et al., 2015; Brownson et al., 2009). As the BEAT assessment involves two experts assessing blue spaces, inter-rater reliability testing should improve the robustness of the tool. The next phase of development therefore, is pilot testing, refining and validating the tool at a number of different blue spaces (to be reported in a later paper). As there is no "gold standard" control site available to compare with, the validity of the BEAT will be tested on its use at different types of blue spaces (e.g. sea, large river, lake) over a wide geographical and climatic coverage within Europe.

6. Conclusions

The BlueHealth environmental Assessment Tool (BEAT) is intended to provide a simple and practical yet comprehensive assessment or audit of blue spaces by experts or professionals, primarily from landscape, planning and environmental management disciplines but also with the potential to be used by community groups and local experts. The tool has been designed primarily for identifying the extent to which a particular blue space provides opportunities for obtaining benefits through exposure to water but also what impacts there might be on the environment itself and what hazards are present (or potentially present) for both environment and people.

The BEAT can be used as a means of collecting data about blue spaces for monitoring purposes (as an indicator set to be used over time), as a starting point in a planning and design project for upgrading, restoring or providing new access to waterfront landscapes, or as a post-occupancy evaluation of a built project. These, in turn, could make judgments about urban public health resource use and promote their use through place improvement or help for securing funding for blue space improvements.

Declaration of Competing Interest

After consideration of the information available to us, we the authors, do not consider this paper to be a conflict of interest with other authors, people or organizations, and our work has not been influenced by any personal or financial relationships with reviewers and editors or any other person or organisation concerned with the review and submission of this paper. We do not consider this paper as an outcome of academic competition and intellectual passion.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ufug.2019.126575.

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